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UNITED STATES AIR FORCE RESEARCH LABORATORY

COMMAND AND CONTROL TEAM PERFORMANCE IN DISTRIBUTED MISSION TRAINING EXERCISES

Samuel G. Schiflett

Air Force Research Laboratory
2504 Gillingham Drive, Bldg 170, Suite 25
Brooks AFB TX 78235-5100

Linda R. Elliott
Mathieu Dalrymple
Philip A. Tessier

Veridian Engineering
PO Box 35482
2504 Gillingham Drive, Bldg 170
Brooks AFB TX 78235

Rebecca Cardenas

NTI
PO Box 35482
2504 Gillingham Drive, Bldg 170
Brooks AFB TX 78235

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AIR FORCE MATERIEL COMMAND
AIR FORCE RESEARCH LABORATORY
HUMAN EFFECTIVENESS DIRECTORATE
WARFIGHTER TRAINING RESEARCH DIVISION
6030 South Kent Street, Bldg 561
Mesa AZ 85212-6061

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SAMUEL G. SCHIFLETT
Project Scientist

DEE H. ANDREWS
Technical Director

JERALD L. STRAW, Colonel, USAF
Chief, Warfighter Training Research Division

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Samuel G. Schiflett
Linda R. Elliott
Mathieu Dalrymple
Philip A. Tessier
Rebecca Cardenas

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Air Force Research Laboratory
Warfighter Training Research Division, Information Systems Training Branch
2504 Gillingham Drive, Bldg 170, Suite 25
Brooks AFB TX 78235-5100

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Ai r Force Research Laboratory
Human Effectiveness Directorate
Warfighter Training Research Division
6030 South Kent Street, Bldg 561
Mesa AZ 85212-6061

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14. ABSTRACT

Distributed mission training (DMT) enables participants to perform within a virtual battlespace created by networking several high fidelity simulations. In a recent exercise, ROADRUNNER '98, several agencies interacted to create battlespace missions in which "friendly" fighter aircraft and command and control (C2) crewmembers participated as trainees while supporting roles and enemy forces were either played by operational personnel (virtual players) or created by intelligent agent technology (constructed forces). Trainees participated in complex war scenarios without cost, safety, and security constraints associated with live-fire training. We describe the assessment of C2 teams within this DMT exercise, comprised of Airborne Warning and Control System (AWACS) weapons directors (WDs) and air surveillance technicians. We describe the process by which C2 teamwork dimensions were identified, measures formulated, and results analyzed. Measures of AWACS team performance were developed based on previous cognitive task analysis data and refined through focal groups comprised of operational AWACS, WDs, or WD instructors.

15. SUBJECT TERMS

Airborne Warning and Control System; AWACS; C2; Command and control; Constructed forces; Distributed mission training; DMT; Live-fire training; ROADRUNNER; Team performance; Team training; Teamwork; Virtual players

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PREFACE

This research was conducted under a contract effort for the Air Force Research Laboratory, Human Effectiveness Directorate, Warfighter Training Research Division (AFRL/HEA). The purpose of this effort was to provide specialized scientific and programming expertise to advance the understanding and implementation of team programming expertise to advance the understanding and implementation of team communication.

The work was conducted under Work Unit 2313-HA-06, Command and control Team Performance in distributed Mission Training Exercises; Contract Number F41624-95-D-6026 with Veridian, Inc. The work unit and laboratory contract monitor was Dr. Samuel G. Schiflett, AFRL/HEAE.

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Requests for reprints should be sent to Dr Samuel G. Schiflett, Air Force Research Laboratory, AFRL/HEAI, Bldg. 170, 2504 Gillingham Dr., Suite 25, Brooks AFB, TX 78235-5104

Command and Control Team Performance in Distributed Mission Training Exercises

Introduction

The use of realistic simulation equipment has been standard practice in military operational training for quite some time. Distributed Mission Training (DMT) takes this concept further, by creating a synthetic battlespace with multiple participants. This is accomplished through networking of simulators to enable a complex battlespace environment filled with live (human in aircraft), virtual (human in simulation), and constructed (computer-driven) forces. It is expected to reduce the number of flight hours while maintaining levels of expeditionary force readiness. DMT is looked upon as a way that will allow warfighters to train in a manner consistent with Air Force Doctrine 60: *Train like you fight, fight like you train.* Previous constraints (e.g., safety, flying status, flying hours, and aircraft and environmental factors) have hampered training efforts from following this philosophy to its fullest capacity. DMT is consistent with the vision explicated by General Fogleman, Chief of Staff Air Force, on 29 Jan 1996:

> *I am convinced modeling and simulation technologies available today will enable us to significantly change the way we train in the future. We are at a crossroads where simulator technology today will be critical in the success of our effective use of follow-on weapon systems .... We need to take a hard look at how this technology will change our training philosophy as well as how we develop future weapon systems.*

DMT offers flexibility that stretches worldwide by linking participants across network lines, allowing individual warfighters to train concurrently within a shared mission scenario. This capability supplements aircrew flight hours with a synthetic reproduction of a complete and complex warfighting environment that combines realistic scenarios with simulated operational systems. It allows individuals to experience the full extent of interdependencies among various players and to participate in debriefing sessions that may not occur in live-fire exercises or in combat situations. For example, the Airborne Warning and Control System (AWACS) crew do not normally debrief with the pilots of fighter aircraft, due to the extended time the AWACS crew are in flight. Thus, blame for errors can easily occur without resolution, due to lack of debrief communication.

The *ROADRUNNER '98* exercise focused primarily on the integration of multiple warfighter-in-the-loop training simulators, combining them with synthetic forces to form a virtual battlespace to conduct several assorted combat-oriented, tactical training exercises. *ROADRUNNER '98* was sponsored by the Air Force Modeling and Simulation Office (USAF/XOC) with the Air Force Research Laboratory, Human Effectiveness Directorate's Warfighter Training Research Division (AFRL/HEA) serving as program managers and the Theater Command and Control Simulation Facility (TACCSF) as systems integrators. Extensive support was received from the Training Office at Air Combat Command's Deputy for Operations (ACC/DOT), the Air Force Information Warfare Center's Advanced Combat Simulations Division (AFIWC/SAM), the AWACS training office at the 522nd Air Control Wing (ACW), the 107th Air Control Squadron (ACS) of the Iowa Air National Guard (IANG), and the Naval Air Warfare Center's Training Systems Division (NAWC-TSD). The warfighters who participated in *ROADRUNNER '98* were operational pilots, weapons directors (WDs), and air surveillance technicians (ASTs) from the 522nd ACW, Tinker AFB, OK; 27th Fighter Wing, Cannon AFB, NM; the 185th and 132nd Fighter Wings of the IANG; 33rd Fighter Wing, Eglin AFB, FL; and from the United States Air Forces in Europe (USAFE).

The overall goal of this effort was to compare initial team performance with subsequent performance after participation, and give the participants the opportunity to critique both the systems and the concept of training (Parton, 1998). Each scenario was based on intelligence briefings and air tasking order (ATO), and each fighter and AWACS team planned, coordinated, and briefed their mission. The combined teams flew the mission in their respective simulators with a "trusted agent" monitoring and evaluating their performances. These trusted agents were AWACS WD instructors who assisted in development of evaluation forms and served as experts for the collection of observed data. The teams and instructors participated in an after-action review aided by a mission playback system that assisted during the debriefing process. Each team participated in seven separate missions over the course of one week.

While DMT offers opportunities for the investigation of performance within highly complex and interdependent scenarios, it also presents additional challenges with regard to identification of training requirements, scenario development, and performance evaluation. One challenge arises when scenarios are expected to provide valuable training experience to all participants. For example, a scenario that is challenging and relevant to the training requirements of fighter aircrew may not produce any challenge for other participants. Additional effort must be directed to the creation of a scenario that provides valuable experience for all participants, and the utilization of constructed forces (computer-based entities driven by intelligent agent technology) to provide supporting roles.

Another challenge inherent in DMT scenarios is the measurement of performance of individual participants, of teams, and of the overall mission. Dwyer, Oser, Salas, and Fowlkes (1999) have discussed the challenges to performance measurement in distributed training environments. These include the geographic separation of players and the rich complexity of tasks and their interactions. They provide sound guidelines for an approach to performance measurement that is linked to training objectives and scenario events, referred to as event-based training (EBT).

In this effort, we utilized this EBT approach for scenario development to refine the AWACS portion of the scenario. Our first challenge lay in the fact that the AWACS mission was more of a supportive role to that of the fighter aircraft performing in Mesa, Arizona. We had to enrich the AWACS roles, identify training requirements, and create trigger events to elicit and evaluate individual and team performance.

At the same time, we wanted to focus on teamwork aspects of performance. Thus, we used this opportunity to further refine a taxonomy of command and control team performance, through focal group interviews of AWACS WD instructors. From this taxonomy, we generated a rating form that was focused on teamwork aspects of performance. Thus, our scenarios were refined through EBT procedures, and our evaluation measures were partially EBT-driven, but supplemented by a more construct-based approach to performance measurement. We wanted to create a taxonomy of command, control, and communication (C3) performance which would be generalizable to other interventions in addition to that of training. For example, in future studies we shall look more closely at the impact of factors such as the distribution and display of information.

Command and Control Teams

All command and control teams share some common task and performance characteristics. These teams perform in highly interdependent roles, tracking and coordinating some type of tactical action, in a manner consistent with overall strategic goals and procedures, for a defined sector of air and/or land space over a sustained period of time.

The AWACS team serves within this performance domain, to augment the need for airborne surveillance and command, control, and communications functions for tactical and air defense forces. They provide the means to detect, identify, track, and intercept airborne threats. The aircraft's god's-eye capability offers an altitude-independent 360° view of more than 200 miles over both land and water. There are five mission crew categories related to the function of the AWACS crew: the Mission Crew Commander (MCC), Senior Director (SD), Weapons Director (WD), Air Surveillance Officer (ASO), and Air Surveillance Technician (AST). AWACS teams typically work in teams of two to four crewmembers as part of the airborne command and control group located within E-3 Sentry aircraft.

The AWACS crew coordinates communications received from a number of sources, such as other WDs, the SD, air surveillance personnel, electronic combat officers (ECOs), intelligence operations, base operations, and friendly pilots. To accomplish this, they must exchange, interpret and effectively weight information and optimize resource allocation decisions across team members, over time, and under stress and fatigue. These decisions depend on sharing resources, such as surface-to-air missile sites and various combat, reconnaissance, refueling, and search and rescue aircraft. Relevant information must be distributed to appropriate personnel and updated over time, in dynamic conditions which may require shift changes in personnel. Information is often verbal, and may be missing, degraded, passed along from unfamiliar sources, or misinterpreted by others. In addition, information is often communicated/interpreted by individuals with only partially overlapping awareness of the battlespace.

Cognitive Task Analyses. For the *ROADRUNNER '98* study, assessment of AWACS team of performance was based on subject-matter expert (SME) ratings of several dimensions. These dimensions were generated based on existing taxonomies of team performance, and cognitive task analyses of AWACS performance, followed by focus groups' interviews of experienced AWACS instructors. These focus groups also served to refine the rating form, and included the SMEs who actually participated as *ROADRUNNER '98* trusted agents/evaluators.

For this effort, cognitive task analyses informed and influenced the development of scenario characteristics and the identification of primary performance constructs and measures. Several cognitive task analyses have been performed on AWACS operational personnel. First, analyses have been performed with regard to AWACS individual tasks, with a primary focus on display enhancements (Klinger et al., 1993). In addition, Fahey and associates (Fahey et al., 1998) investigated the AWACS task domain with a special focus on AWACS team tasks, utilizing cognitive task analysis and critical incident techniques for data elicitation. Their report provides a comprehensive description of the AWACS task, and the general finding that critical incident technique was quite useful for the description of AWACS teamwork. In addition, a team-based analysis of AWACS tasks was performed (MacMillan et al., 1998). Results were very informative, supporting frameworks and constructs within an information-requirements approach to task descriptions.

Identification of C3 Teamwork Constructs

The starting point to identify C3 teamwork constructs began in our search for core characteristics of teamwork performance in general. We reviewed existing taxonomies and identified several compelling alternatives (Baker & Salas, 1992; Cannon-Bowers, Oser, & Flanagan, 1992; Fleishman & Zaccaro, 1992; Hackman & Morris, 1975; Kozlowski, 1998; O'Neil, Baker, & Kazlauskas, 1992; Smith-Jentsch, Johnston, & Payne, 1998; Sundstrom, De Meuse, & Futrell, 1990; Swezey, Meltzer & Salas, 1994). It is evident that teams span a diverse array of functions. Several taxonomies have provided some key distinguishing factors among these teams (Salas, Bowers, & Cannon-Bowers, 1995; Salas, Dickinson, Converse, & Tannenbaum, 1992; Sundstrom, et al., 1990; Swezey, et al., 1994). Others have focused on components relevant to teamwork training and adaptive expert performance (Andrews, Waag, & Bell, 1992; Baldwin & Magjuka, 1997;Blickensderfer, Cannon-Bowers, & Salas, 1998; Bowers, Baker, & Salas, 1994; Eggemeier, Fisk, Robbins, & Lawless, 1988; Ford, Kozlowski, Kraiger, Salas, & Teachout, 1997; Goldsmith & Kraiger, 1997; Kozlowski, 1998; Kozlowski, Gully, McHugh, Salas, & Cannon-Bowers, 1996; Kozlowski, & Salas, 1997; Kozlowski, Gully, Nason, & Smith, 1999; Kraiger, Ford, & Salas, 1993; Mathieu & Martineau, 1997; Mathieu, Tannenbaum, & Salas, 1997; McIntyre & Salas, 1995; Salas, Cannon-Bowers, & Blickensderfer, 1997; Salas, Cannon-Bowers, & Johnston,; 1997; Salas, Cannon-Bowers, & Kozlowski, 1997; Smith, Ford, & Kozlowski, 1997; Serfaty, Entin & Johnston, 1998; Smith-Jentsch, Johnston, & Payne, 1998; Smith-Jentsch, Zeisig, Acton, & McPherson, 1998; Swezey & Salas, 1992; Tannenbaum, Smith-Jentsch, & Behson, 1998).

Each taxonomy was useful for its particular domain and purpose, however, we were searching for a taxonomy that could possibly distinguish teams in general. Constructs in some of the taxonomies did not map directly on team performance in command and control teams. For example, communication and coordination are often used as positive indicators of teamwork. However, in C3 teams, the environment constrains communication, and more effective teams communicate less often and coordinate in more anticipatory ways. This reliance on information-push rather than information pull, or implicit coordination, has been related to C3 team effectiveness in more controlled settings (Serfaty et al., 1998).

Thus, while existing taxonomies were very useful, we began instead by considering the core definition of teams. Teams are distinguished from groups in general by a common purpose or goal, performed by interdependent team members (Salas et al., 1992). From this definition we can then derive a sub-definition, of teamwork per se, in that the fundamental function of teamwork can be defined as the effective managing of interdependencies to accomplish a team. The importance of considering type and degree of interdependence when characterizing teams has been discussed (Saavedra, Earley, & Van Dyne, 1993; Salas, et al., 1992). Rather than explicating behaviors that may (or may not) be related to the management of interdependencies, we then focused on identification of the nature of these interdependencies. We started with six functional dimensions of team interdependence which could be referred to in distinguishing types of teams (Schiflett & Elliott, in review). This framework was later refined, particularly to distinguish coordination which was based on task execution of a plan (however complex) from the construct of dynamic replanning (Elliott, Hollenbeck, Schiflett, & Dalrymple, in review).

Our generic taxonomy serves as an overarching framework to distinguish teams in general, across performance domains, with regard to the nature and extent of teamwork demands. Assuming the essence of teamwork is the managing of team member interdependencies, we identified two core dimensions with regard to nature and extent of interdependencies, that of (a) coordination complexity (static) and (b) adaptive replanning (dynamic). A brief description follows.

Coordination Complexity. Assuming interdependencies exist, teams will vary in the degree to which these interdependencies can be articulated in advance. For example a symphony can explicate its interdependencies among team members to very specific terms, by articulating synchronized procedural strategies (who must do what, with whom, and when), given a score of music.

Assuming the coordination plan is explicit, quantitative delineation of the coordination flow would yield an estimate of coordination complexity. Evaluation of team coordination can then be based on adherence to the plan to provide a measure of coordination efficiency. Many approaches exist which can provide indices of both coordination efficiency (of the plan) and coordination performance, as determined by execution of the plan (Bowers, Baker, & Salas, 1994; Coovert, & McNelis,1992; Coovert & Craiger, 1997; Coovert, Craiger, Cannon-Bowers, Driskell, & Salas, 1995). Entire disciplines have focused on the quantification of efficiency. Highly sophisticated mathematical modeling techniques are arising from numerous quantitative disciplines and are becoming increasingly user-friendly through advances in PC technology. Many of these models have been applied to the performance domain of command and control, to ascertain the effectiveness of various team task architectures and/or to generate more effective structures (Benson, Kemple, Kleinman, Porter, & Serfaty, 1998; Brehmer, 1992, 1998; Curry, Kleinman, & Pattipati, 1998; Kleinman, 1998; Krackhardt & Carley, 1998; Handley, Zaidi, & Levis, 1998; Lee & Carley, 1998; Levchuk, Pattipatti, & Krackhardt & Carley, 1998; Levchuk, Pattipati, & Kleinman, 1998; Levchuk, Lou, Levchuk, Pattipati, & Kleinman, 1999; Serfaty, 1996; Paley, Levchuk, Serfaty, & MacMillan, 1999). Thus, the opportunity exists to model and evaluate the efficiency and execution of coordination plans of very complex interactions.

In the modeling of complex team performance, it is necessary to consider and evaluate the allocation of resources as well as the allocation of tasks among team members. For example, given an overall task goal, one usually finds a sequence of tasks which must be accomplished, resources for task accomplishment, and individuals to perform the tasks. To generate a coordination plan, tasks must be assigned to resources, and to individuals, in some (hopefully) efficient and effective manner. Factors to consider include (a) allocation of tasks to team members (simple to complex); (b) allocation of resources to team members (simple to complex); (c) degree of performance monitoring (implicit coordination requirement); and (d) degree of information exchange (explicit coordination requirement).

Our fundamental vision for a model of coordination complexity represents the degree to which team members must manage prespecified interdependencies with regard to tasks and resources in order to accomplish their mission. Measurement would reflect the degree of complexity in terms of coordination demand.

Adaptive Dynamic Replanning. A second independent dimension of teamwork regards the degree to which team members must adapt to dynamic circumstances. Teams may be very low on coordination complexity as defined by the complexity of a prespecified plan, and yet still have a high requirement for adaptive teamwork—to rework the plan, and re-allocate tasks and/or resources. Given a dynamic environment, teams must be able to problem solve and replan "on the fly." It then becomes difficult, and perhaps unfair, to evaluate the team through adherence to a prespecified coordination of action. Teams in general can be distinguished with regard to the degree to which the team/leader must generate coordination strategies during performance execution as opposed to following a predetermined and static plan. Certainly, execution of a complex reciprocal coordination plan can be challenging even if determined beforehand, but the task requirement is different when plans must be revised or improvised during performance execution. The contrast is obvious between orchestra versus jazz bands, or theatre acts versus performance art. However, most teams will vary in more moderate levels for both static and dynamic aspects of coordination. For example, most sports teams have a repertoire of "strategies," and also a set of contingencies for switching strategies if the current strategy is not working well.

In AWACS teams, there can be high levels of both coordination complexity and adaptive replanning. This is reflected in the importance of premission planning where team members are informed of the mission goals, strategies, and constraints. The team leader then facilitates planning operational procedures, generating a communication protocol, and explicating contingencies with the other team members. They also coordinate with other entities (e.g., pilots) with whom they must interact during mission execution, ascertaining rules and terms to facilitate and clarify later communications. This planning phase is critical when scenarios are complex, demanding, and/or likely to change. During this time, team members assign responsibilities and formulate contingency plans for unexpected events. Thus, while most of the planning is performed in advance, there may be need for dynamic replanning, particularly if the planning was not performed well to start, and/or unexpected events arise.

Discussion with focal groups comprised of AWACS subject-matter experts led to further refinement of our team task taxonomy as it applies to AWACS team performance. Prior to the *ROADRUNNER '98* exercise, we interviewed 38 expert AWACS weapons directors. These groups were interviewed to provide feedback and refine the teamwork constructs, the DMT mission scenarios, and the team observer evaluation form. Review of the initial taxonomy, which was generated to classify teams in general, led to the identification of four teamwork functions which are specific to AWACS teamwork: (a) mission planning, (b) communication content/timing, (c) adherence to communication protocol, and (d) dynamic replanning (see Figure 1).

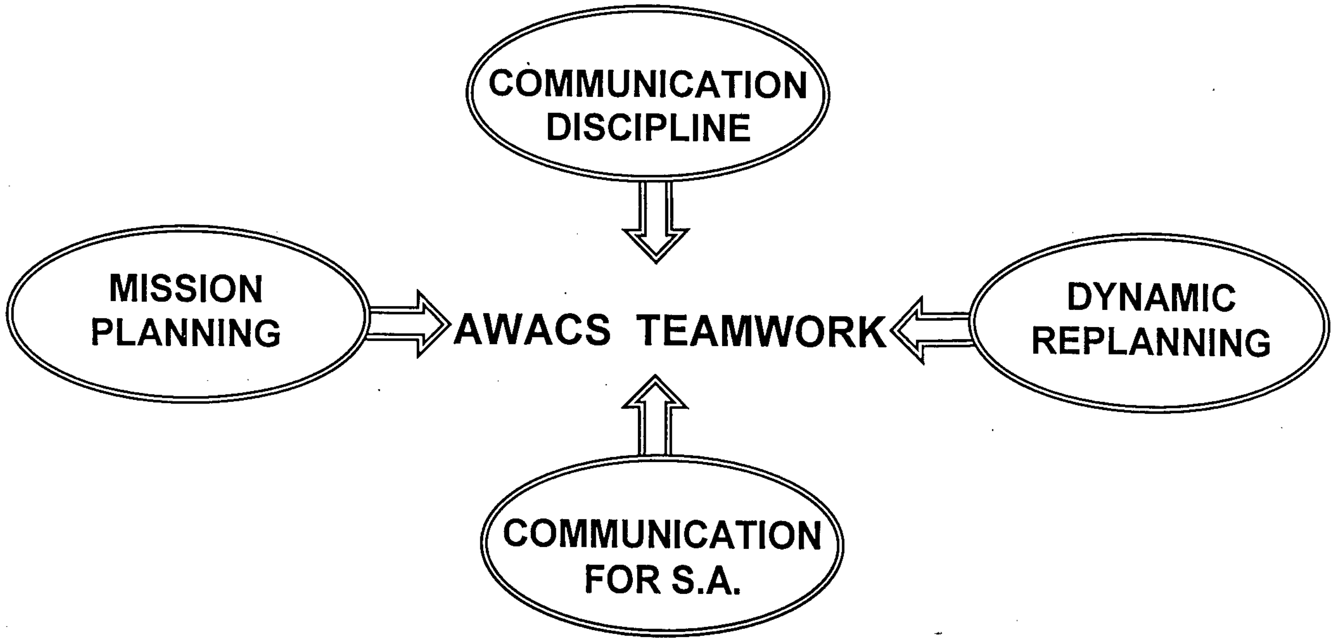

Figure 1. Core Functions of AWACS Teamwork

Mission planning: formulation of "contracts." AWACS performance can be divided into three phases: premission planning, task execution, and debriefing (discussion after task execution). Mission planning affects AWACS teamwork by establishing roles, responsibilities, and contingency plans. As discussed by Fahey et al. (1998) and Macmillan et al. (1998) AWACS weapons directors explicate roles, responsibilities, and strategies to manage team member interdependencies through the establishment of "contracts." These contracts are made among AWACS team members (internal contracts) and to the "external" team (i.e., pilots of friendly assets). In addition, WD focus groups strongly endorsed the importance of this construct.

Planning may greatly influence the flexibility of teams during performance through two mechanisms—preliminary task allocation (delineation of objectives, roles, and responsibilities) and explication of contingencies. First, the task responsibilities of the AWACS WD are articulated during the premission briefing. Responsibilities may be distributed geographically, such that WDs are performing more like generalists, each performing similar broad duties but responsible for a different geographical area. However, they may also be distributed functionally, so that one WD may be responsible for "offense," another for "defense," and another for refueling of assets, and all work across the entire geographic area. In this functional configuration, it is easier for each member to maintain awareness of the entire battlespace, thus increasing shared awareness, but coordination demands among members are higher. The manner of task allocation thus directly affects both coordination complexity and adaptive flexibility.

A second way planning affects adaptive performance is through explication of contracts and contingencies. During the premission briefing, "contracts" are formed among the team members, which assign and describe roles and responsibilities. These contracts include the task allocations, but also address additional details and contingencies, such as review of the flow of aircraft assigned to each WD (ingress/egress, sequence, timing, role, aircraft positioning), expected enemy tactics and anticipated/ pre-briefed actions by friendly aircraft, the assignment of communication channels, and scope setup assignments. Scope setup includes issues like who will initiate update of display features such as track initiations, special points, restricted areas, etc.; how / what will be displayed during the different phases of the mission (e.g., the primary controller may have minimum information displayed and be concentrating on radar data while another may have a more cluttered display); and contingencies for scope problems.

In the communications setup, planning typically addresses how communications will be configured and identifies the responsibilities for each person during each phase of the mission—such as who will monitor/talk on specific radio frequencies, what is the priority of information to be passed from assist to the primary WD, the radio plan, and the format for passing information from assist to primary (for example, point and talk, time share frequency, or grab-arm technique). Emergency contingencies are also discussed and roles/responsibilities assigned. These reflect some of the many details included in well-formulated contracts. There are numerous additional details that can be discussed; one characteristic of a good mission planner is the ability to recognize, given a particular mission, which details should be emphasized.

Communication discipline: adherence to protocol. AWACS weapons director tasks are based predominately on the exchange of verbal information. Communications are heavily standardized in terms of content (jargon) and process. This aspect of communication effectiveness refers to the degree to which individuals follow guidelines for communication exchange. In addition to proper jargon and syntax, communications must be clear, concise, and correct. This construct was identified in all cognitive task analyses and by the focal groups, and is an explicit and important aspect of WD training that applies across all mission scenarios.

Communication for shared situation awareness: content, timing. Communications may be clear, concise, correct, and delivered according to proper protocol and still be superfluous. The maintenance of shared situation awareness also requires that pertinent information be exchanged with the right person, at the right time. In such a communication-rich environment, too much communication can impede performance when unnecessary information "steps over" other, more urgent communication. Indeed, part of the proper timing of AWACS communications involves knowledge of when to keep quiet, particularly when communicating to pilots.

Dynamic Replanning. This construct started off as supportive behavior, as suggested by existing taxonomies of team performance. However, while it would seem apparent that supportive behavior would be relevant, the conceptualization of supporting behavior among AWACS weapons directors was difficult to validate through SMEs. While there was no doubt that AWACS team members do support each other, the argument was made that most of the support is in the form of communication exchange, already captured as constructs. AWACS team members support each other primarily through updates and reminders of salient information.

We then discussed the nature of dynamic replanning and its relevance to AWACS team performance; this was very highly endorsed. In fact, team members appreciated the more academic nature of the "dynamic replanning" label, as compared to their own references, which were more interesting and colorful. The common factor here is the need to recognize when plans are no longer effective, generate alternatives, and suggest/decide upon a new course of action.

It should be noted here that these constructs are meant to be core functions that comprise AWACS teamwork. There are likely to be additional behaviors, such as the monitoring of other team member performance, which would also be related to teamwork. However those behaviors are predicted to affect teamwork through their affect on one of these functions. Thus, monitoring other team members would be expected to affect the degree to which communications support shared situation awareness, or the timeliness of problem recognition. Also, additional behaviors may be more dependent on mission scenario. Monitoring of others may be critical for teamwork in one scenario, yet unnecessary for another. We wanted to ascertain the core functions that are demanded across scenarios.

Development of Rating Instrument

Once the dimensions of AWACS teamwork performance were refined by the SME focus groups, the rating instrument was tailored to capture these dimensions across three phases of performance: (a) premission planning, (b) mission performance, and (c) mission debriefing. Ratings were based on traditional rating assessment categories. The rating categories used are based on the same categories of performance used in AWACS WD training. A description of the rating scale and evaluation form is provided in the appendix.

Premission planning. WDs were rated on the following during the planning phase of their performance. The development of mission aids including the generation, refinement, and review of the communications worksheet (which specifies who talks to whom on which channel), the fighter flow sheet, the chart, and the fact sheet, all of which describe and/or specify procedures to enhance awareness and coordination. Formulation of internal contracts refers to the agreements made among the WDs as to their roles and responsibilities. Communication tasks and console assignments are set, specific mission objectives are discussed, and functional responsibilities and contingency plans are specified and assigned. Formulation of external contracts refers to the procedures executed between the WDs and others (pilots) with regard to roles and responsibilities, such as those regarding objectives, strategies, and communications. These contracts are then discussed within the briefing session by the lead WD with the lead pilot, along with issues such as the rules of engagement (ROE) and ATO compliance.

Mission Execution. Performance during mission execution was assessed by ratings regarding (a) communication in accordance with Air Force Tactical Publication and Unit Standards, (b) communications in support of situation awareness and the "big picture", and (c) overall mission execution, as specified during premission planning and adaptive problem solving. Communications are assessed in terms of adherence to established protocol, which strives to maximize aspects of clarity, brevity, and accuracy—communications that are clear, concise, and correct. This includes communications among WDs (labelled "internal") and also their communications to others (labelled "external"). In addition, communications are also rated with regard to relevance and timeliness—is the information what was needed to maintain team situation awareness—was the right information "pushed" to the right person at the right time? Communication for situation awareness was also rated for within-team (internal) and to others (external). Mission execution was assessed through consideration of ATO execution, contract execution (formulated during premission briefing), and adaptive replanning (flexibility, problem-solving, contingency generation as needed).

Mission Debriefing. Performance during mission debriefing was assessed through ratings of (a) reconstruction of the engagement, (b) evaluation of team objectives, (c) review of equipment issues, (d) review of team mission execution, and (e) review of communications. Reconstruction of the engagement was assessed through consideration of the process of reviewing the recordings and the identification of conflicts and/or problems. Objectives were reviewed in light of mission support and execution of contracts. Equipment issues included communication, console assignments, and any failures/alibis. Team mission execution was assessed through consideration of priority objectives, training objectives, and any failures/alibis. Communications was considered with regard to within-team (internal) information exchange and also communications to others (external). Communications should have supported overall situation awareness, and lessons learned should be identified during the mission debriefing.

Each team was rated on the various aspects of performance, described previously, within each of three phases of performance, for each mission. They were assessed for performance in Phase I (premission briefing), Phase II (mission execution), and Phase III (mission debriefing).

Results

Descriptive Statistics. Table 1 provides mean performance ratings across teams and scenarios. Results indicate a good amount of variance in distribution in ratings, with utilization of the entire rating scale, for most measures. This indicates the scenarios were neither too difficult nor too easy, but were sufficiently challenging to distinguish team member's performance. It also indicates that the measures chosen were aspects of performance that differed among team members. We did not have measures where all team members excelled or failed. Of interest were relationships among measures, and the degree to which measures were affected by (a) the rater (source of error), (b) the team (how different were the teams in their performance and were there particular aspects that most differentiate them, and (c) experience over time.

Table 1. Average Ratings across Teams, Scenarios, Raters

	N	Min	Max	Mean	Std. Dev
Premission Planning					
Mission Aids	25	2.00	4.00	3.0800	.4933
Internal Contracts	25	2.00	4.00	2.9600	.6758
External Contracts	24	1.50	4.00	2.8125	.6726
Prebrief with Pilots	24	1.00	4.00	2.8542	.6833
Planning Overall	25	1.88	3.75	2.9200	.4703
Task Execution					
Internal Communications	42	1.00	4.00	2.9881	.7690
External Communications	42	1.00	4.00	2.7143	.7741
Sit Awareness (Internal)	42	1.00	4.00	2.9524	.7949
Sit Awareness (External)	42	1.00	4.00	2.6905	.8762
Mission Execution (Internal)	42	1.00	4.00	3.0000	.7730
Mission Execution (External)	41	1.00	4.00	2.6951	.9413
Overall Mission Execution	42	1.33	4.00	2.8421	.7301
Debrief					
Reconstruction of Events	24	2.00	4.00	3.1250	.6124
Discussion of Equipment	26	2.00	4.00	3.1154	.4961
Communications (External)	25	1.00	4.00	3.0400	.8406
Communications (Internal)	24	1.00	4.00	2.9792	.8140
Discuss. Team Performance	24	2.00	4.00	3.0417	.7929
Discuss. of Mission Outcome	24	1.00	4.00	3.0833	.8805
Overall Debrief	27	1.50	4.00	3.0562	.5970
OVERALL across 3 phases	22	1.94	3.69	2.8699	.4705

Rater Error. Analysis of Variance (ANOVA) indicated no significant differences among raters with regard to any of the measures. In addition, regression analyses based on the consideration of trusted agents, teams, and scenarios indicate that the variance attributable to differences among trusted agents was not significant (see Table 2).

Table 2. Overall Regression Model Summary: Raters, Teams, Scenario Experience (Training)

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
	.859	.738	.694	.2603

Sum of Squares		*df*	*Mean Square*	*F*	*Sig.*
Regression	3.429	3	1.143	16.867	.000
Residual	1.220	18	6.776E-02		
Total	4.648	21			

	t	*Sig.*
(Constant)	11.750	.000
TRUSTEDA	-.969	.345
TEAM	-2.436	.025
SCENARIO	6.557	.000

Relative impact of raters, teams, and scenarios. There were three primary sources of variance: that attributable to raters (which should be minimized), to differences among teams (not of primary interest here), and to the training exercise itself (differences among the seven scenarios were predicted to demonstrate improvement over time). Multiple regression analyses were performed, first on the model composed of trusted agents, teams, and scenarios. This model predicted 73% of the total variance in ratings. In addition, the consideration of trusted agents did not add to the prediction of ratings, thus indicating reliability of measures with regard to raters

These data indicate that performance improved across all teams for most measures of performance over the three phases of performance. Results are described in further detail for the effects due to differences among teams and differences across scenarios.

Differences among teams. Data demonstrate the advantage in careful development of performance constructs. The overall measure of performance was based on the mean of all measures; ANOVA results did not indicate significant differences among teams. There were, however differences among teams for the measurement of one aspect (negotiation of contracts among team members) of performance during premission briefing, and for nearly all aspects of performance during mission execution. Teams did not differ significantly in performance during mission debriefing. An overall assessment of performance may be too generic to capture effects of a predictor variable.

Table 3: Performance Ratings with Significant Differences Between Teams

ANOVA

Variable	**Sum of Squares**	**df**	**Mn Sq**	**F**	**Sig.**
Planning: Internal Contracts	3.363	2	1.681	4.869	.018**
Mission Execution-External	5.730	2	2.865	3.665	.035**
Sit. Awareness-External	4.298	2	2.149	3.083	.057*
Sit. Awareness-Internal	4.762	2	2.381	4.392	.019**
Communications-External	3.857	2	1.929	3.631	.036**
Communications-Internal	2.869	2	1.435	2.617	.086*
Overall Mission Execution	3.298	2	1.649	3.466	.041**

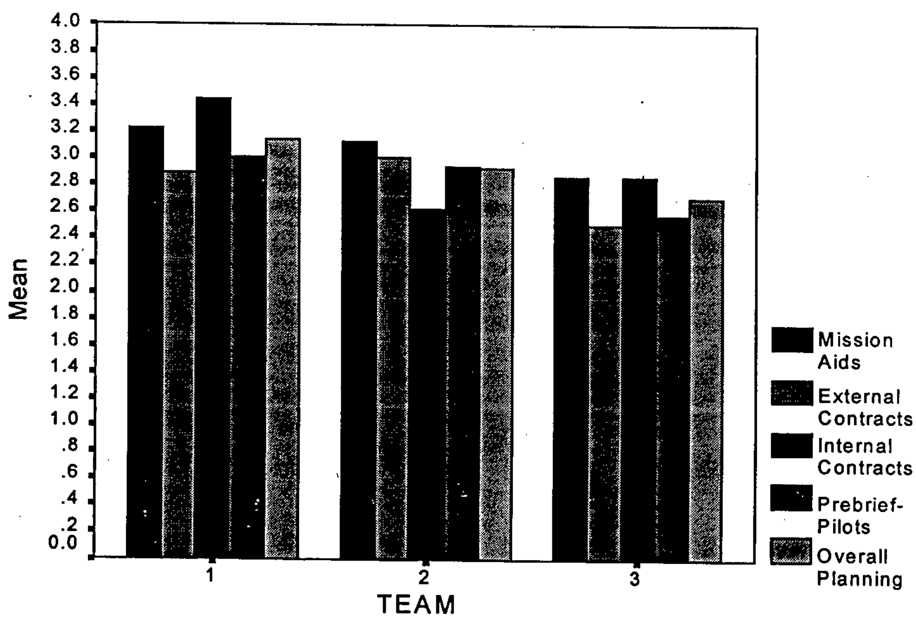

Figure 2. Performance of Teams in Mission Planning

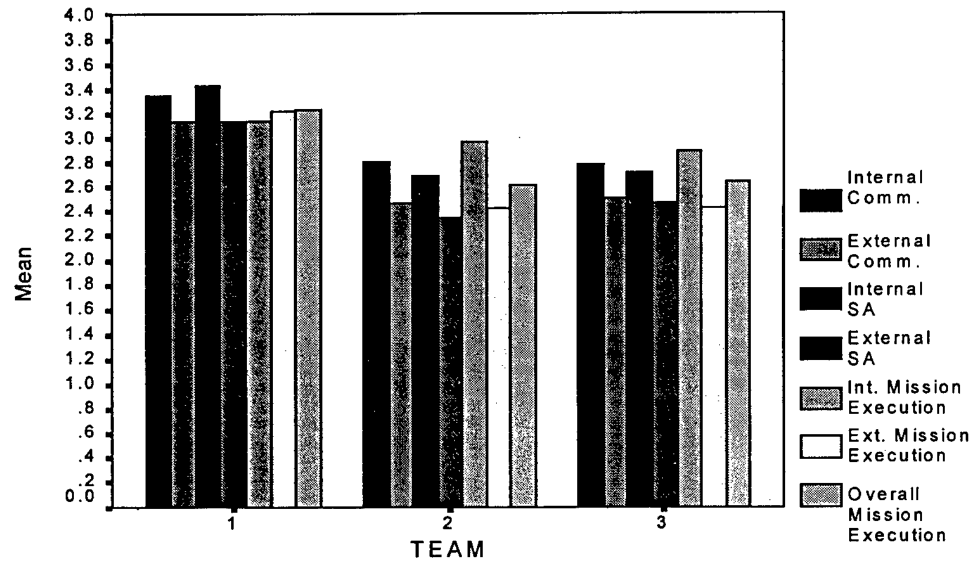

Figure 3. Performance of Teams in Mission Execution

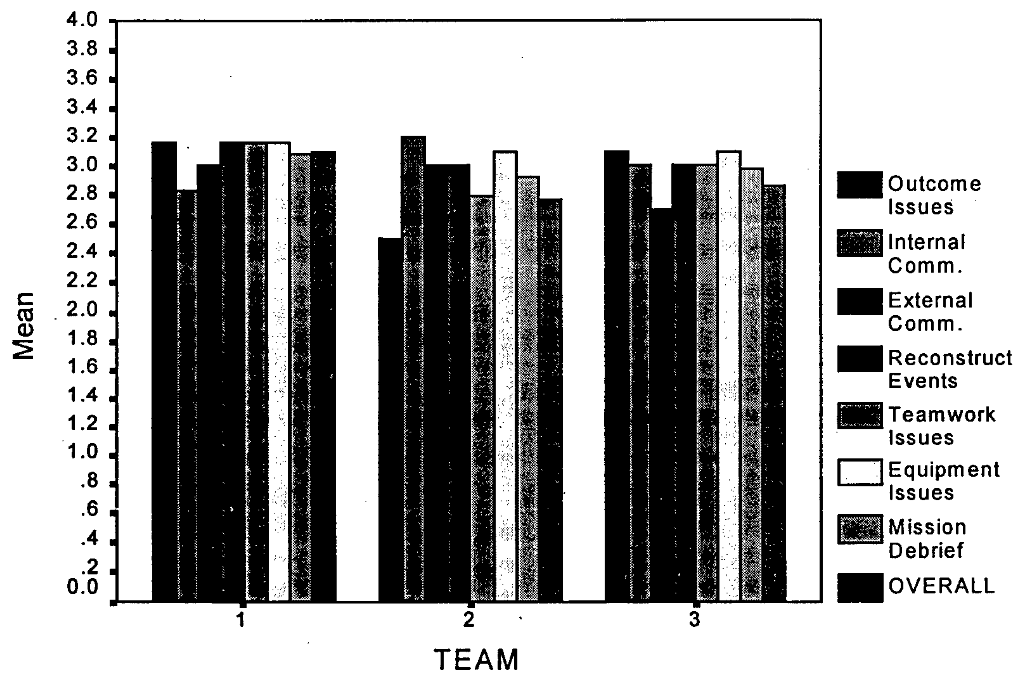

Figure 4. Performance of Teams in Mission Debriefing

Impact of training experience. Team performance differed significantly across scenarios for many of the measures (See Appendix for descriptives and ANOVA output). Differences in measures among scenarios would capture differences due to the scenario content, as scenarios differed in mission objective and content. They would also be due to experience over time. Scenario 1 and Scenario 7 were developed to be very similar in mission and task demands, to better ascertain the effect of experience on performance. The following graph (fig. 5) describes overall results of instructor ratings of AWACS team performance, for each mission session, ordered over time.

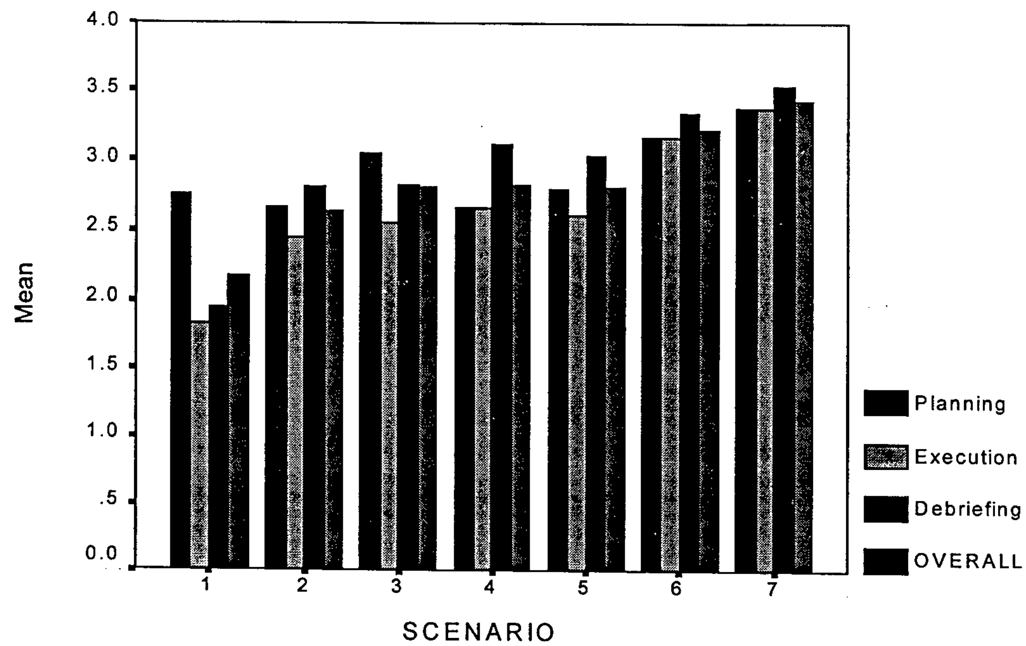

Figure 5. Averaged Team Performance for each Phase and Scenario, Over Time.

Figure 5 provides a succinct glimpse of trends regarding the effect of simulation participation on performance, through differences in performance from Scenario 1 and Scenario 7, by phase. Here it can be seen that variance in performance across scenarios was more attributable to performance in Mission Execution and Debriefing: teams were lower in performance during these phases during the first scenario, and demonstrated higher improvement in these phases. At the same time, performance during premission briefing also improved over time.

Team 1 was the highest performing team for both pre and post scores. Improvement for this team was consistent across the three phases. In comparison, Teams 2 and 3 performed less well from the start, and particularly less well in mission execution and debriefing. Data indicate that training needs exist for the kind of training that distributed mission training provides: Improvement in team premission briefing, team coordination, and team debriefing. In addition, data demonstrate the effectiveness of participation in the training exercise for the improvement of performance across all phases of each mission.

Discussion

Assessment of individual and team performance in realistic combat training environments requires (a) the capability to produce complex and dynamic scenarios, (b) identification of constructs that represent important individual and team skills, and (c) identification and/or development of construct measures. Ideally, scenarios should include embedded events that link training requirements, performance assessment, and performance feedback (Dwyer, et al., 1999). In addition, each scenario must have quantitative criteria of mission success.

Simulation-driven distributed mission training was expected to add value through the experience of complexity of team-on-team interdependencies. The immersion of individuals into teams within a global mission scenario should enhance their capability of managing these interdependencies during performance. For these exercises, the expanded scope of the debriefing experience was found to be particularly valuable to AWACS crew as they do not usually debrief with pilots after an operational mission. An AWACS crew stays in flight well beyond the time of performance of a particular set of combat aircraft.

Results were consistent with expectations. Teams demonstrated significant improvement in several aspects of performance of premission planning, mission execution, and mission debriefing. In addition, while measures of overall performance, based on averaged ratings were not sensitive to differences, significant differences in performance were demonstrated for particular aspects of performance, thus indicating the advantage of careful construction of performance constructs.

REFERENCES

Andrews, D. H., Waag, W. L. & Bell, H. H. (1992). Training technologies applied to team training: Military examples. In R. Swezey & E. Salas (Eds.), Teams: Their training and performance Norwood NJ: Ablex Publishing Corp.

Baldwin, T., & Magjuka, R. (1997). Organizational context and training effectiveness. . In J. Kevin Ford, S. Kozlowski, K. Kraiger, E. Salas, & M. Teachout (Eds.), Improving training effectiveness in work organizations. Mahwah, NJ: Lawrence Erlbaum Associates.

Baker, C & Salas, E. (1992). Principles for measuring teamwork skills. Human Factors, 34 (4), 469-475.

Benson, R., Kemple, W., Kleinman, D., Porter, G., & Serfaty, D. (June, 1998). An example of model-based empirical research: A soup-to-nuts evaluation of alternative C2 architectures. Proceedings of the 1998 Command and Control Research and Technology Symposium., Monterey, CA: Naval Postgraduate School.

Blickensderfer, E., Cannon-Bowers, J., & Salas, E. (1998). Cross-training and team performance. In J. Cannon-Bowers & E. Salas (Eds.), Making Decisions Under Stress: Implications for individual and team training. (pp. 2) Wash DC: APA Press.

Bowers, C., Baker, D., & Salas, E. (1994). Measuring the importance of teamwork: The reliability and validity of job/task analysis indices for team-training design. Military Psychology, 6 (4), 205-214.

Brehmer, B. (1992). Dynamic decision making: Human control of complex systems. Acta Psychologica, 81, 211-241.

Brehmer, B. (1998). Distributed Decision Making in Dynamic Environments. Proceedings of the 1998 Command and Control Research and Technology Symposium. Monterey, CA: Naval Postgraduate School.

Cannon-Bowers, J. A., Oser, R., & Flanagan, D. L. (1992). Work teams in industry: A selected review and proposed framework. In R. Swezey & E. Salas (Eds.), Teams: Their training and performance. Norwood NJ: Ablex Publishing Corp.

Coovert, M., & Craiger, J. P. (1997). Performance modeling for training effectiveness. In J. Kevin Ford, S. Kozlowski, K. Kraiger, E. Salas, & M. Teachout (Eds.) Improving training effectiveness in work organizations. Mahwah, NJ: Lawrence Erlbaum Associates.

Coovert, M.; Craiger, J., Cannon-Bowers, J., Driskell, J., & Salas, E. (1995). Innovations in modeling and simulating team performance: Implications for decision making. In Guzzo & Salas, (Eds.). Team effectiveness and decision making in organizations. San Francisco: Jossey-Bass.

Coovert, M. & McNelis, K. (1992). Team Decision making and Performance: A review and proposed modeling approach employing Petri Nets. . In R. Swezey & E. Salas (Eds.), Teams: Their training and performance. Norwood NJ: Ablex Publishing Corp.

Curry, M., Kleinman, D., & Pattipatti, K. (June, 1998). On mission planning: A foundation for organizational design. Proceedings of the 1998 Command and Control Research and Technology Symposium. Monterey, CA: Naval Postgraduate School.

Dwyer, D.J., Oser, R., O., Salas, E., & Fowlkes, J. (1999). Performance measurement in distributed environments: Initial results and implications for training. Military Psychology, 11 92), 189-215.

Eggemeier, F. T., Fisk, A. D., Robbins, R. J., & Lawless, M. T. (1988). Application of automatic/controlled processing theory to training tactical C3 skills: II. Evaluations of task-analytic methodology. Proceedings of the annual meeting of the Human Factors Society, Santa Monica, CA.

Elliott, L. R., Hollenbeck, J. R., Schiflett, S. G., & Dalrymple, M. (In Review). Investigation of situation awareness and performance in realistic command and control scenarios. In Review for M. McNeese, E. Salas, & M. Endsley (Eds.) "Group Situational Awareness: New Views of Complex System Dynamics."

Fahey, R.P., Rowe, A., Dunlap, K. & DeBoom, D.(in review). *Synthetic task design (1): Preliminary cognitive task analysis of AWACS weapons director teams.* Technical Report. Brooks AFB, TX: Armstrong Laboratory.

Fleishman, E., & Zaccarro, S. (1992). Toward a taxonomy of team performance functions. In R. Swezey & E. Salas (Eds.) Teams: Their training and performance. Norwood NJ: Ablex Publishing Corp.

Fogleman, General. *Chief of Staff Air Force: Perspective.* 29 Jan 96

Ford, J. K., Kozlowski, S., Kraiger, K., Salas, E., & Teachout, M. (1997). Improving training effectiveness in work organizations. Mahwah, NJ: Lawrence Erlbaum Associates.

Goldsmith, T. & Kraiger, K. (1997). Structural knowledge assessment and training evaluation. In J. Kevin Ford (Ed.), Improving training effectiveness in work organizations. Mahwah, NJ: Lawrence Erlbaum Associates.

Hackman, J.R. & Morris, C.G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), Advances in Experimental Psychology, 8, 45-49. New York: Academic Press.

Handley, H., Zaidi, Z., & Levis, A. (June, 1998). Pre-experimental modeling of adaptive organizational architectures. Proceedings of the 1998 Command and Control Research and Technology Symposium. Monterey, CA: Naval Postgraduate School.

Kleinman, D.L., & Serfaty, D. (1998). Normative-descriptive modeling of human teams: A 15-year perspective. Proceedings of the 1998 Command and Control Research and Technology Symposium. Monterey, CA: Naval Postgraduate School.

Klinger, D.W., Andriole, S.J., Militello, L.G., Adelnam, L., Klein, G. & Gomes, M.E. (1993). *Designing for performance: A cognitive systems engineering approach to modifying an AWACS human-computer interface* (AL/CF-TR-1993-0093, AD A275187). Wright-Patterson AFB, OH: Armstrong Laboratory.

Kozlowski, S. W. J. (1998). Training and developing adaptive teams: Theory, principles, and research. In J. A. Cannon-Bowers & E. Salas (Eds.), In J. Cannon-Bowers and E. Salas (Eds.) Making decisions under stress. Washington D.C.: APA Press.

Kozlowski, S., Gully, S., McHugh, P., Alas, E., & Cannon-Bowers, J. (1996). A dynamic theory of leadership and team effectiveness: Developmental and task contingent leader roles. Research in Personnel and Human resources Management, 14, 153-305.

Kozlowski, S. & Salas, E. (1997). An organizational systems approach for the implementation and transfer of training. In J. Kevin Ford (Ed.) Improving training effectiveness in work organizations. Mahwah, NJ: Lawrence Erlbaum Associates.

Kozlowski, S., Gully, S., Nason, E., & Smith, E. (1999). Developing adaptive teams: A theory of compilation and performance acreoss levels and time. In D. Ilgen & E. Pulakos (Eds.), The changing nature of performance: Implications for staffing, motivation, and development. San Francisco, CA: Jossey-Bass.

Krackhardt, D., & Carley, K. (1998). A PCANS model of structure in organizations. Proceedings of the 1998 Command and Control Research and Technology Symposium. Monterey, CA: Naval Postgraduate School.

Kraiger, K., Ford, J. K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation (Monograph). Journal of Applied Psychology, 78, 311-328.

Lee, J., & Carley, K. (June, 1998). Adaptive strategies for improving C2 performance. Proceedings of the 1998 Command and Control Research and Technology Symposium. Monterey, CA: Naval Postgraduate School.

Levchuck, G., Levchuk, Y., Luo, J., Tu, F., & Pattipatti, K. (2000). A Library of Optimization Algorithms for Organizational Design. Proceedings of the 2000 Command and Control Research and Technology Symposium (A2C2 session), June-July, Monterrey, CA.

Levchuk, Y., Kleinman, D., Pattipati, K., Kemple, W., & Luoma, M. (2000). Assessment of a Model-based Organizational Design Methodology in Bridge to Global '99. Proceedings of the 2000 Command and Control Research and Technology Symposium (A2C2 session), June-July, Monterrey, CA.

Levchuck, Y., Pattipatti, K., & Kleinman, D. (June, 1998). Designing adaptive organizations to process a complex mission: Algorithms and Applications. Proceedings of the 1998 Command and Control Research and Technology Symposium. Monterey, CA: Naval Postgraduate School.

MacMillan, J., Serfaty, D., Young, P., Klinger, D., Thordsen, M., Cohen, M., Freeman, J. & Elliott, L.R. (1998) *A system to enhance team decisionmaking performance (AFRL-HE-AZ-TR-1998-0138). Mesa AZ: Air Force Research Laboratory, Warfighter Training Research Division.*

Mathieu, J. & Martineau, J. (1997). Individual and situational influences in training motivation. In J. Kevin Ford (Ed.), Improving training effectiveness in work organizations. Mahwah, NJ: Lawrence Erlbaum Associates.

Mathieu, J., Tannenbaum, S, & Salas, E. (1997). The influences of individual and situational characteristics on measures of training effectiveness. Academy of Management Journal.

McIntyre, R., & Salas, E. (1995). Measuring and managing for team performance: Emerging principles from complex environments. In Guzzo & Salas (Eds.), Team effectiveness and decision making in organizations. San Francisco: Jossey-Bass.

O'Neil, H. F., Jr., Baker, E. L., & Kazlauskas, E. J. (1992). Assessment of team performance. In R. Swezey & E. Salas (Eds.), Teams: Their training and performance. Norwood, NJ: Ablex.

Parton, Randy. (7 Aug 98) *ROADRUNNER '98 After Action Report.*

Saavedra, R., Earley, P.C & Van Dyne, L. (1993). Complex interdependence in task-performing groups. *Journal of Applied Psychology*, 78 (1), 61-72.

Salas, E., Bowers, C. A., & Cannon-Bowers, J. A. (1995). Military team research: 10 years of progress [Special Issue]: Team processes, training, and performance. Military Psychology, 7 (2), 55-75.

Salas, E., Dickinson, T., Converse, S. & Tannenbaum, S. (1992). Toward an understanding of team performance and training. In R. Swezey & E. Salas (Eds.), Teams: Their training and performance. Norwood NJ: Ablex Publishing Corp.

Salas, E., Cannon-Bowers, J., & Blickensderfer, E. (1997). Enhancing reciprocity between training theory and training practice: Principles, guidelines, and specifications. In J. K. Ford (Ed.), Improving Training Effectiveness in Work Organizations. Mahwah, NJ: Lawrence Erlbaum Associates.

Salas, E., Cannon-Bowers, J., & Johnston, J. (1997). How can you turn a team of experts into an expert team? Emerging training strategies. In C. Zsambok & G. Klein (Eds.), Naturalistic Decision Making. Hillsdale, NJ.

Salas, E., Cannon-Bowers, J. A., & Kozlowski, S. (1997). The science and practice of training: current trends and emerging themes. In J. K. Ford (Ed.) Improving training effectiveness in work organizations. Mahwah, NJ: Lawrence Erlbaum, Ass.

Schiflett, S. & Elliott, L. R.. (in review). Development of synthetic team training environments: Application to USAF command and control aircrews. To appear in H. O'Neil & D. Andrews (Eds.), Aircrew Training: Methods, Technologies, and Assessment.

Serfaty, D., Entin, E., & Johnston, J. (1998) Team coordination training. In J. Cannon-Bowers & E. Salas (Eds.), Making decisions under stress. Washington, DC: American Psychological Association.

Smith, E. M., Ford, J. K., & Kozlowski, S. W. J. (1997). Building adaptive expertise: Implications for training design. In M. A. Quinones & A. Dudda (Eds.), Training for a rapidly changing workplace: Applications of psychological research (pp.89-118). Washington, DC: APA Books.

Smith-Jentsch, K., Johnston, J., & Payne, S. (1998). Measuring team-related expertise in complex environments. In J.A. Cannon-Bowers & E. Salas (Eds.) Making decisions under stress. Washington, DC: APA Press.

Smith-Jentsch, K., Zeisig, R., Acton, B, & McPherson, J. (1998). Team dimensional training: A strategy for guided team self-correction. In J. Cannon-Bowers & E. Salas (Eds.), Making decisions under stress: Implications for individual and team training. Wash DC: APA Press.

Sundstrom, E., de-Meuse, K., & Futrell, (1990). Work teams: Applications and effectivenesss. American Psychologist 45 (2), 120-133.

Swezey, R., Meltzer, A., & Salas, E. (1994). Some issues involved in motivating teams. In In H. O'Neil, & M. Drillings (Eds.), Motivation: Theory and Research. Lawrence Erlbaum Ass. Hillsdale New Jersey.

Swezey, R. L & Salas, E. (1992). Guidelines for use in team training development. In R. W. Swezey & E. Salas (Eds.), Teams: Their training and performance. Norwood NJ: Ablex Publishing Corp.

Tannenbaum, S., Smith-Jentsch, & Behson, S. (1998). Training team leaders to facilitate team learning. In J. Cannon-Bowers & E. Salas (Eds.) Making decisions under stress: Implications for individual and team training. Wash DC: APA Press.

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Appendix: Rating scales developed for AWACS team performance *

NAME (*Last, First, MI*)				TEAM NUMBER						SCENARIO	DATE
	GRADE										TIME
MISSION ELEMENTS/EVENTS	NO	NP	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4				
I. Phase I: Plan										REMARKS	
A. Develop MSN Aids	NO	NP	0	1	2	3	4				
B. Contracts Within AWACS	NO	NP	0	1	2	3	4				
1. Comm 2. Set-up 3. MSN Tasks (Primary/Assist) AST, SD 4. Other?											
C. Pre-brief Pilots	NO	NP	0	1	2	3	4				
1. Goals 2. Philosophy 3. ATO compliance											

NO = Not Observed

NP = Not Performed

0 = Lack of Ability or Knowledge. Mission Failure

1 = No Proficiency (Lack of Knowlege, Coordination, Communication, Cohesion). Uncorrected Errors. Degraded Mission Outcome or Endanger Friendly Forces.

2 = Limited Proficency. Recognizes & Corrects Errors with Team Recovery. Mission Degraded.

3 = Proficient. No mission impacting errors. Team reacts correctly in current situations.

4 = Highly Proficient. Prevents errors. Team anticipates future errors.

* This form extends further to the right to provide room for comments.

II. Phase II: Mission Execution										REMARKS
A. Comm										
Within Team	NO	NP	0	1	2	3	4			
Outside Team	NO	NP	0	1	2	3	4			
1. Correct Format 2. Vocabulary 3. Clarity 4. Brevity 5. To Right Person										
B. S/A & Picture										
Within Team	NO	NP	0	1	2	3	4			
Outside Team	NO	NP	0	1	2	3	4			
1. Timeliness (Cadence) 2. Content (Relevant?) 3. Accurate 4. Anticipatory (Future state)										
C. MSN Tasking										
Within Team	NO	NP	0	1	2	3	4			
Outside Team	NO	NP	0	1	2	3	4			
1. Contract Execution (Compliance) 2. Adaptive Replanning (Flexibility, Problem-Solving, Contingency)										

NO = Not Observed

NP = Not Performed

0 = Lack of Ability or Knowledge. Mission Failure

1 = No Proficiency (Lack of Knowlege, Coordination, Communication, Cohesion). Uncorrected Errors. Degraded Mission Outcome or Endanger Friendly Forces.

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II. Phase II: Mission Execution										REMARKS
A. Comm										
Within Team	NO	NP	0	1	2	3	4			
Outside Team	NO	NP	0	1	2	3	4			
1. Correct Format 2. Vocabulary 3. Clarity 4. Brevity 5. To Right Person										
B. S/A & Picture										
Within Team	NO	NP	0	1	2	3	4			
Outside Team	NO	NP	0	1	2	3	4			
1. Timeliness (Cadence) 2. Content (Relevant?) 3. Accurate 4. Anticipatory (Future state)										
C. MSN Tasking										
Within Team	NO	NP	0	1	2	3	4			
Outside Team	NO	NP	0	1	2	3	4			
1. Contract Execution (Compliance) 2. Adaptive Replanning (Flexibility, Problem-Solving, Contingency)										

NO = Not Observed

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